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Until this is forthcoming from those travelers and explorers who are now working in this especial field the Basin Range hypothesis shall have to be considered as holding a place among those hypotheses yet unproven, and as an assumption of very doubtful utility.

CHARLES KEYES

SCIENTIFIC BOOKS

Mechanism, Life and Personality. By J. S. HALDANE. New York, Dutton. 1914. Pp. viii + 139. Price, \$1.00.

I

Dr. J. S. Haldane has long been known as a philosophical physiologist. Indeed it is now for more than three decades that he has occasionally relieved the labors of an orthodox and eminent scientific investigator with the pleasures of idealistic metaphysics. At length he has constructed his philosophy of biology into a little book, "Mechanism, Life and Personality," which he offers as a contribution towards "bringing the great biological movement of the nineteenth century into definite relation with the main stream of human thought."

The first half of this book is devoted to an examination of "the hypothesis that living organisms may be regarded as conscious or unconscious physical and chemical mechanisms, and can be satisfactorily investigated from this standpoint." Such is Haldane's statement of the mechanistic theory of life. Many considerations favor such a theory. Chemical analysis reveals no mysterious substances or reactions within the body, general physiology and the study of metabolism reveal no mysterious forms or manifestations of energy, and to all appearances the laws of the conservation of matter and the conservation of energy there hold. Consciousness, to be sure, is a difficulty, but, at any rate, consciousness seems not to interfere with the operation of any law of physics or of chemistry. Moreover, when once we have commenced the analysis of organisms, whether physically or chemically, we find no structure but physical and chemical structure, no activity but physical and chemical activity.

Historically too there is much to justify the mechanistic view, for "the history of physiol-

ogy displays uninterrupted progress in the successful application of physical and chemical methods to physiological problems."

In the manifold and inconceivably intricate phenomena of organic regulations the mechanist has found serious difficulties. But in the course of time, as the mechanistic nature of nervous control, of the action of hormones, and of similar phenomena were discovered, this difficulty has grown less. Again the very existence of such marvellous physical and chemical structures as living things once seemed mechanistically quite inexplicable. But when Darwin conceived the principle of natural selection this difficulty was removed.

In his zeal to do full justice to the mechanistic theory Haldane even goes so far as to declare that it is possible to imagine how life may have originated. This is perhaps too much, for I suspect that some chemists would still prefer the first chapter of Genesis to the mechanist's guesses upon the subject.

As for the traditional opponents of the mechanistic view, the vitalists and the animists, their theories have ever been sterile. Occasionally encouraged by the collapse of one or another mechanistic theory, their own efforts have nevertheless ended in mere words, for "the apparent autonomous selective action of the organism turns out to be causally dependent in every detail on physical and chemical conditions." Therefore the action of any possible vital principle must be determined by these conditions.

Further the vitalistic theory implies "a definite breach in the fundamental law of the conservation of energy" (according to Driesch not in the first but in the second law of thermodynamics). Moreover the vitalistic agency is itself "entirely unintelligible."

On the other hand, even if the position of the vitalists and animists is entirely unsatisfactory, that does not establish the justice of the mechanistic theory. We must not forget that a living thing never does *seem* to be a mechanism, especially to those who know it well and study it as a whole, that is as a real *organism*. In particular to identify stimulus and response with physical and chemical causation, a belief

which is the very basis of the mechanistic physiology, is "a gigantic leap in the dark." To be sure, the difficulty of making out this causal connection might be due solely to the complexity of the cell, nevertheless "the point must be emphasized that in the case of stimulus and response there is in reality no experimental evidence whatsoever that the process can be understood as one of physical and chemical causation." No real quantitative relation between the supposed cause and the effect can be traced.

No doubt such information as we now possess will continue to increase, biophysics and biochemistry to unfold, but there is no reason to suppose that this kind of information will in the future serve as an explanation of that which in the past it has totally failed to explain.

Historically, in spite of the great services of physics and chemistry to biology, "the mechanistic theory has, on the whole, fared very badly." Cell-growth and cell-nutrition, absorption and secretion, have not been mechanistically explained. Mechanistic theories of respiration and metabolism, of muscular movement and other physiological movements, have also failed. And as the science develops we seem to get further and further away from any prospect of success in such enterprises. In truth ignorance alone could have justified the earlier crude mechanistic theories of the intracellular processes. For "what the mechanistic theory must assume in the case of an organism such as man is a vast assemblage of the most intricate and delicately adjusted cell-mechanisms, each mechanism being so constituted as to keep itself in working order year after year, and in exact coordination with the working of the millions of other cell-mechanisms which make up the whole organism."

But the facts of reproduction and heredity involve still greater difficulties, for we have reason to believe that the whole adult mechanism has come from the nuclear material of the fertilized germ cell. "On the mechanistic theory this nucleus must carry within its substance a mechanism which by reaction with the environment not only produces the millions of

complex and delicately balanced mechanisms which constitute the adult organism, but provides for their orderly arrangement into tissues and organs, and for their orderly development in a certain perfectly specific manner." And yet, according to the mechanistic view, this structure of inconceivable complexity is capable of dividing itself to an indefinite extent while retaining its original structure. "The real difficulty for the mechanistic theory is that we are forced, on the one hand, to postulate that the germ-plasm is a mechanism of enormous complexity and definiteness, and, on the other, that this mechanism, in spite of its absolute definiteness and complexity, can divide and combine with other similar mechanisms, and can do so to an absolutely indefinite extent without alteration of its structure. On the one hand we have to postulate absolute definiteness of structure, and on the other absolute indefiniteness."

Hence, says Haldane, the mechanistic theory of heredity is impossible.

The mechanistic theory of heredity must involve in its downfall every other part of biology. "If we can not frame a mechanistic theory of heredity we are equally at a loss in connection with the ordinary phenomena of metabolism, and we have no right to use mechanistic hypotheses in connection with these phenomena." And finally Haldane concludes: "The phenomena of life are of such a nature that no physical or chemical explanation of them is remotely conceivable."

This conclusion leads to the second half of the book which begins with a philosophical discussion of the nature of reality. Out of this is developed the Hegelian conclusion "that a special category or categories ought to be added (to those of the physical sciences) for organic life, as the idea of life is one of the fundamental ideas. There is no reason why a category or general conception of life should not be just as much constitutive of our experience as the category of substance. Here, therefore, we have a possible way out of our difficulties with the mechanistic theory of life. In trying to reduce life to physical and chemical mechanism we are perhaps in some way con-

fusing two different categories. Kant's general philosophical conclusions have in any case thrown a quite new light on our conceptions of the physical world, and have taught us that the validity of these conceptions is of a very different nature from what was previously believed. It may be that just as we can not base physics on the purely mathematical conceptions of extension, so we can not base biology on the purely physical conceptions of matter and energy."

The whole living structure is organized, every part is definitely related to every other part. This is also true of its activity or metabolism. Thus it has come about that "in dealing with life we not only use a whole series of special terms, but these terms appear to belong to a specific general conception which is never made use of in the physical sciences." "The fundamental mistake of the mechanistic physiologists of the middle of last century was that they completely failed to realize this. Such processes as secretion, absorption, growth, nervous excitation, muscular contraction, were treated as if each was an isolable physical or chemical process, instead of being what it is, one side of a many-sided metabolic activity, of which the different sides are indissolubly associated."

"Our ordinary language as applied to life corresponds to these characteristics. We naturally speak of a living organism as an autonomous active whole, and think of it as such. The idea of its being a mechanism made up of separable parts, and actuated by external causes, is wholly unnatural to us, and becomes more and more unnatural the more we know about organisms."

"The concept we are using is radically different from any physical concept: for in conceiving what is living we do not separate between matter or structure and its activity."

"If we assume that the conception of the living organism is the fundamental conception of biology, it is clear that the aim of biology differs entirely from what it would be if the mechanistic theory were accepted. All attempts to trace the ultimate mechanism of life must be given up as meaningless."

On the contrary, the goal of biology must be the description of the organism as an organic unit. This proposition is illustrated by a discussion of the physiology of respiration, and the conclusion is reached that "the idea which gives unity and coherence to the whole of the physiology of respiration is that of the organic determination of the phenomena." And in general by means of this conception "we introduce order and intelligibility into biology, whereas there is no such order or intelligibility if the mechanistic theory of life be adopted."

Finally it is necessary to take account of one other characteristic of the higher organisms, of consciousness. Haldane's conclusion upon this point is as follows:

"We must, it seems to me, draw a sharp and clear distinction between biology, which deals simply with organic life, and psychology, which deals with conscious life or personality. This distinction is similar in general nature to that which I have already endeavored to draw between physics and biology. Just as biology is a more concrete science, nearer to reality than physics and chemistry, so psychology is a more concrete science than biology. We can abstract from the psychological aspect of a man or animal, and regard him only from the biological aspect. This is, in fact, what we do in physiology. In regard to most of the details of bodily activity there is little need for deliberate abstraction, since the psychological element lies only in the background. But when we come to deal with the bodily parts more immediately concerned in perception and voluntary response the case is very different. Perception, voluntary response, and conscious activity of every kind belong to personality, and therefore can not as such be dealt with scientifically from the merely biological or physiological standpoint. We might as well attempt to establish physics on a basis which totally disregards the facts on which the conceptions of mass and energy are based, as to establish psychology on a merely physiological basis."

"Physiology deals, and ought to deal, with living organisms just in so far as the observa-

tions relating to them can be ordered in terms of the conception of a living organism. Where, and in so far as, the conception of a mere organism fails, as in the facts relating to conscious activity, we must have recourse to another conception, that of personality."

"It is evident that in applying the conception of personality to man or animal we leave out of account the details of organic activity. But the details are there, and the only account we are in a position to give of them is in terms of the lower or less concrete conception of mere organic activity. If we go still further into detail we are reduced to a still more abstract account in terms of physics and chemistry. Hence although in giving an account of perception and volition as a whole we make use of the conception of personality, and can not otherwise state the facts, there is abundant room left for a physiological account of the sense organs, nervous system, muscular activity, etc., provided that we recognize that such an account always deals abstractly with the phenomena, for the sufficient reason that a fuller and more concrete account can not at present be given. In the same way we treat the action of the muscles on the limbs, or of the limbs on the environment, or of the environment on the sensory organs, from the merely physical standpoint. This is an abstract method of treatment, as we have already seen; but it is to some extent the only method available. Provided we do not make the mistake of confusing the physical account of the world with reality, we are perfectly justified in making all the use we can of this physical account."

II

It is no light task for a man of science to form a critical judgment of this book, for I believe that its weakness is on the philosophical side. Certain it is that there is great justice in Haldane's strictures upon the supporters of the mechanistic view. Not only have mechanistic theories of physiological actions been almost uniformly of a childish crudeness, falling far beneath the complexity of the facts, but the mechanists have indeed, in the past, failed

to recognize the significance of organization. And for my part I think that Haldane is quite right in establishing organization as something of a different order from mechanism, and elevating it into a category. The mechanists, having been obliged to isolate the phenomena, because such is the necessary condition for the physical and chemical study of them, have forgotten what they have done, and have not thought about organization at all.

It is, however, one thing to recognize the weakness of particular mechanistic theories of the past, or the difficulty, or even the inconceivability, of a mechanistic theory of heredity, and it is quite another thing to conclude that such a theory is impossible, especially in the face of Morgan's recent researches. The explanation of that which Darwin explained was once inconceivable. And one wonders what Galileo or Newton would have done with an electric battery if he had been asked to explain it as a mechanism. It is quite true that we possess no clue to the mechanism of the cell in general as distinguished from important particulars; it is perhaps probable that the task is too great for the human mind, but it is not possible by such a discussion as Haldane has given in the first part of his book to prove its ideal impossibility. The cell is a contrivance unlike anything which we understand, but so for Newton would have been an electric battery, and without further information he simply could not have begun to think about it.

When we turn to Haldane's philosophical objections to the mechanistic standpoint we encounter, as I believe, grave inconsistencies in his argument. True it is that "we can not base physics" *exclusively* "on the purely mathematical conceptions of extension," but physics would be in a very bad way indeed in an ungeometrical universe, or if it were obliged to get on without geometry. Geometry has no need of physics, it is true, though Archimedes showed how to solve geometrical problems by means of mechanics, but physics has imperative need of geometry. Geometry knows neither mass nor energy, but physics knows and uses points and lines.

In exactly like manner physical science has no need of the idea of organization, and knows it not. But biology, with organization as its central fact, both knows and uses physics and chemistry. Logically the less abstract encloses and includes the more abstract. The more abstract meantime preserves its full validity in the domain of the less abstract, just as, for example, the laws of number and extension hold in the physical sciences. So generally true is this that there is hardly any need of seeking illustrations. Haldane's own studies are studies of the organization of the physical and chemical processes of respiration. There can be no doubt that the idea of organization is what informs and interprets such investigations, and that it is an indispensable aid in their pursuit. Quite recently, for example, it has successfully guided Cannon in his researches on the physiology of fear and rage.

There is even a possibility, we may note in passing, in a certain restricted field, of pursuing the study of organization without regard to physics and chemistry. But that field is quite different from physiology, it is the field of animal behavior. In physiology there is no such possibility.

The truth seems to be that the relation of an organism to cellular mechanisms is not unlike the relation of a symphony to the sound waves which bear it to the ear. It is absurd to regard the symphony as merely the sum of the waves of sound, just as it is absurd to regard the organism as merely the sum of the biophysical and biochemical phenomena. But it is quite as absurd to deny that the sound waves are in a very real sense (even if they are not in "reality") the component parts of the symphony. They are, moreover, the only component parts which at present can be profitably investigated, as the difference between the substantial character of musical science, and our vague ideas about the individuality of thematic material well shows. If we turn to Haldane's own experimental researches we shall find that that is precisely his own standpoint as a practical physiologist; he analyzes the phenomena of organization into their component physical

and chemical parts. If then "all attempts to trace the ultimate mechanism of life must be given up as meaningless," that can be only because there are only mechanisms, no *ultimate* mechanism of life. And for my own part I am obliged to say regarding his statement: "The phenomena of life are of such a nature that no physical or chemical explanation of them is remotely conceivable," that it is true only in a sense quite different from its apparent meaning, and is of no *scientific* interest.

A sound understanding of the relation between organic unity and physical phenomena involves no hypothesis regarding the nature of the external world or of reality. It may in the past have had a tendency to involve false ideas upon that subject in much the same way that the practical life of affairs does. But in physiology as in physics there is, I believe, no need to worry about the nature of reality. If the physiologist has foolish or mistaken notions on that subject, it is his private concern. Such ideas may affect his attitude toward the world; they do not affect his attitude toward his science. For in that he is dealing not with "reality," but with "truth," and the "truth" of his physical and chemical discoveries, when properly attested, is of exactly the same order as the truth of a proposition in geometry or of a law of harmony, which is enough.

Another characteristic of Haldane's thought is that he seems to attribute more value to concrete than to abstract scientific knowledge. From the purely metaphysical point of view such an attitude is quite intelligible. But scientifically it appears to be a matter of taste. The mathematical law will always have its devotees, and it will be many a day before such men will see in the progress of psychology anything to equal Newton's "Principia" in interest, in value or in greatness. And yet I am persuaded that such men will heartily recognize the concept of organization for what it is. They must then admit the need of Haldane's most interesting and timely discussion of a very difficult subject, and repay him with their gratitude.

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